GOES-R AWG Product Validation Tool Development

Derived Motion Winds

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OUTLINE

- Derived Motion Wind Product
- Validation Strategies
- Routine Validation Tools
- “Deep-Dive” Validation Tools
- Ideas for the Further Enhancement and Utility of Validation Tools
- Summary

Derived Motion Winds Product

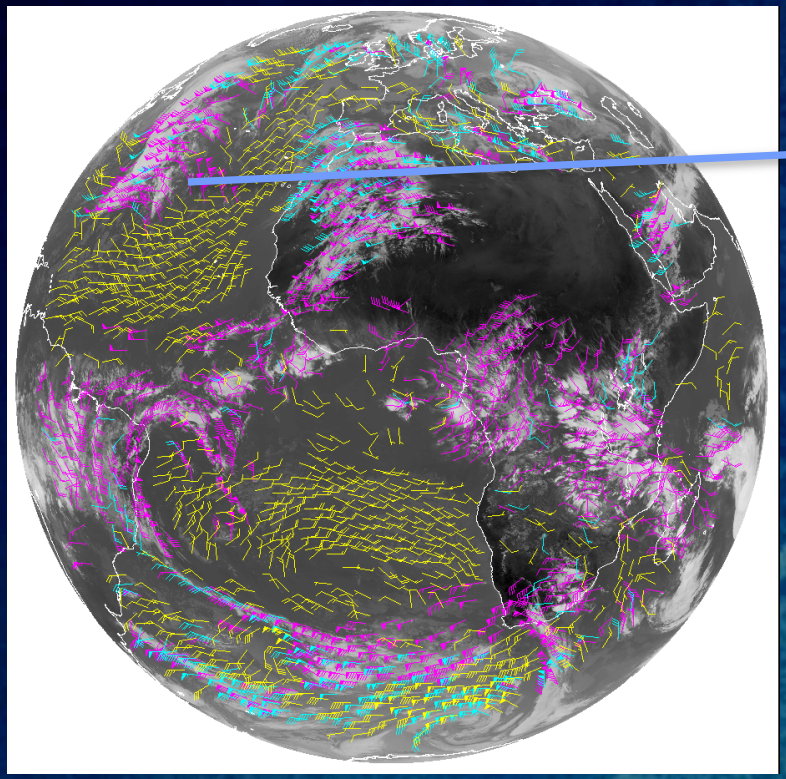
Requirements for…

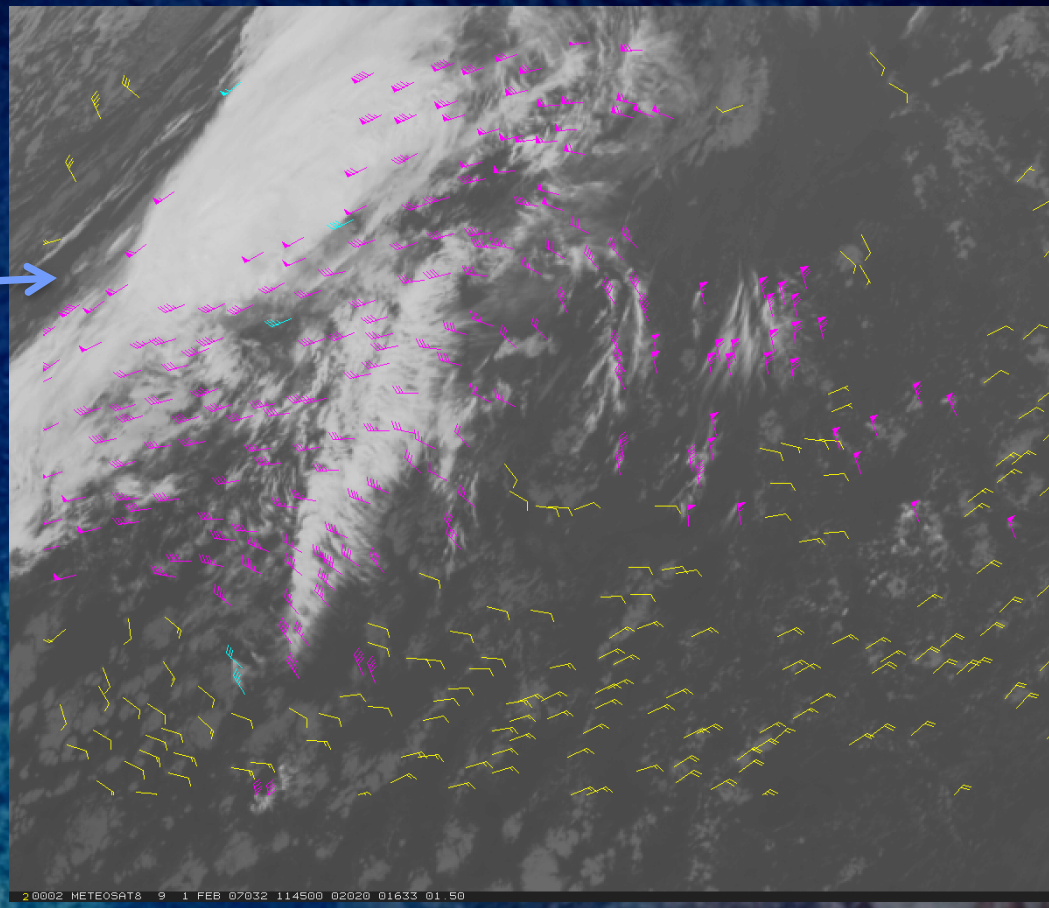
Coverage	Horizontal Resolution	Measurement Range	Accuracy	Precision	Refresh Rate	Latency
Full Disk	38 km	**Speed:** 5.83-300 kts (3-155 m/s) **Direction:** 0 to 360 degrees	7.5 m/s	4.5 m/s	60 min (based on a single set of 3 sequential images 5 or more minutes apart)	806 s
CONUS	38 km	**Speed:** 5.83-300 kts (3-155 m/s) **Direction:** 0 to 360 degrees	7.5 m/s	4.5 m/s	15 min	806 s
Mesoscale	38 km	**Speed:** 5.83-300 kts (3-155 m/s) **Direction:** 0 to 360 degrees	7.5 m/s	4.5 m/s	5 min	806 s

Example Output

Long-wave IR Cloud-drift Winds

Cloud-drift Winds derived from a Full Disk Meteosat-8 SEVERI 10.8 μm image triplet centered at 1200 UTC 01 February 2007





High-Level 100-400 mb

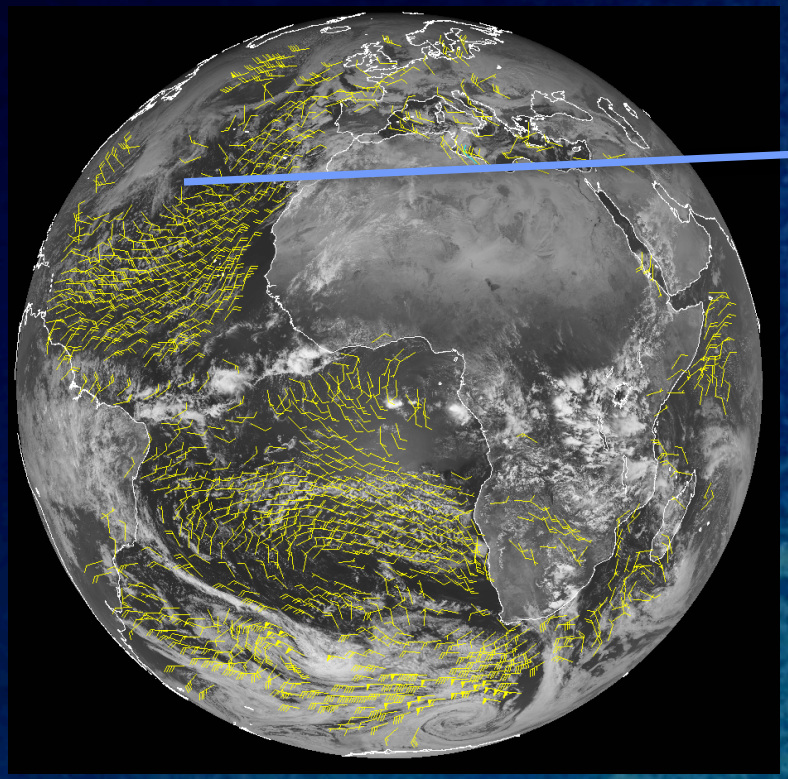
Mid-Level 400-700 mb

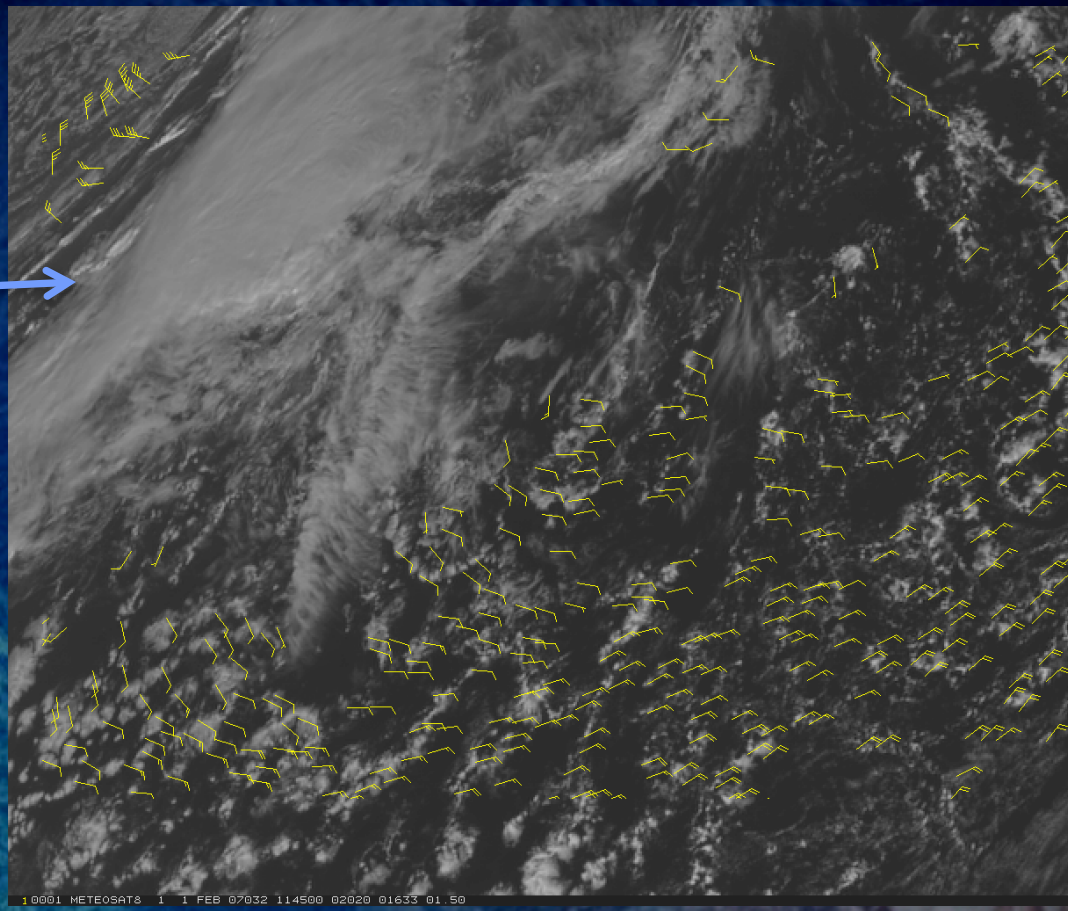
Low-Level >700 mb

Example Output

Visible Cloud-drift Winds

Cloud-drift Winds derived from a Full Disk Meteosat-8 SEVERI 0.60 um image triplet centered at 1200 UTC 01 February 2007



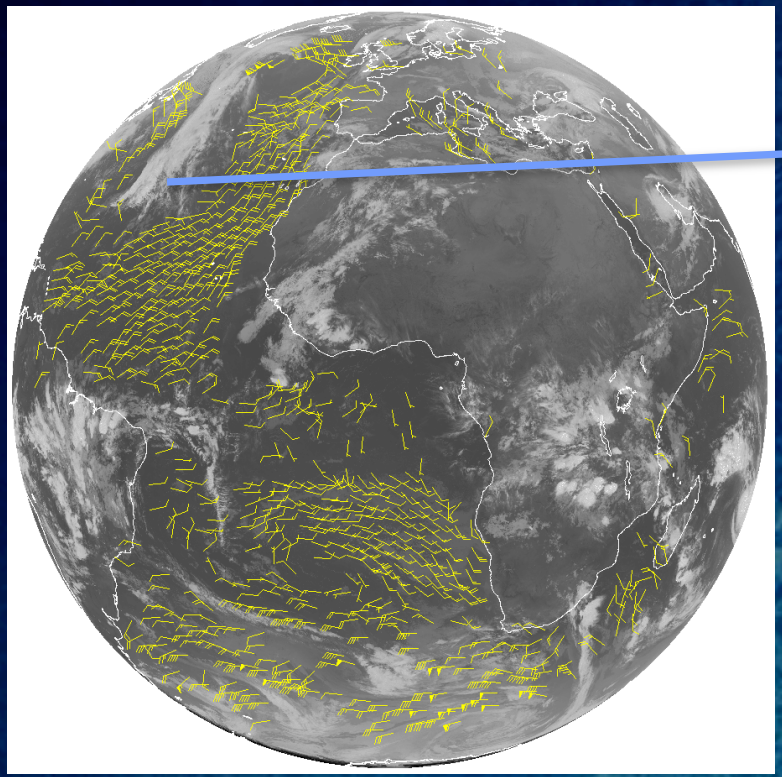


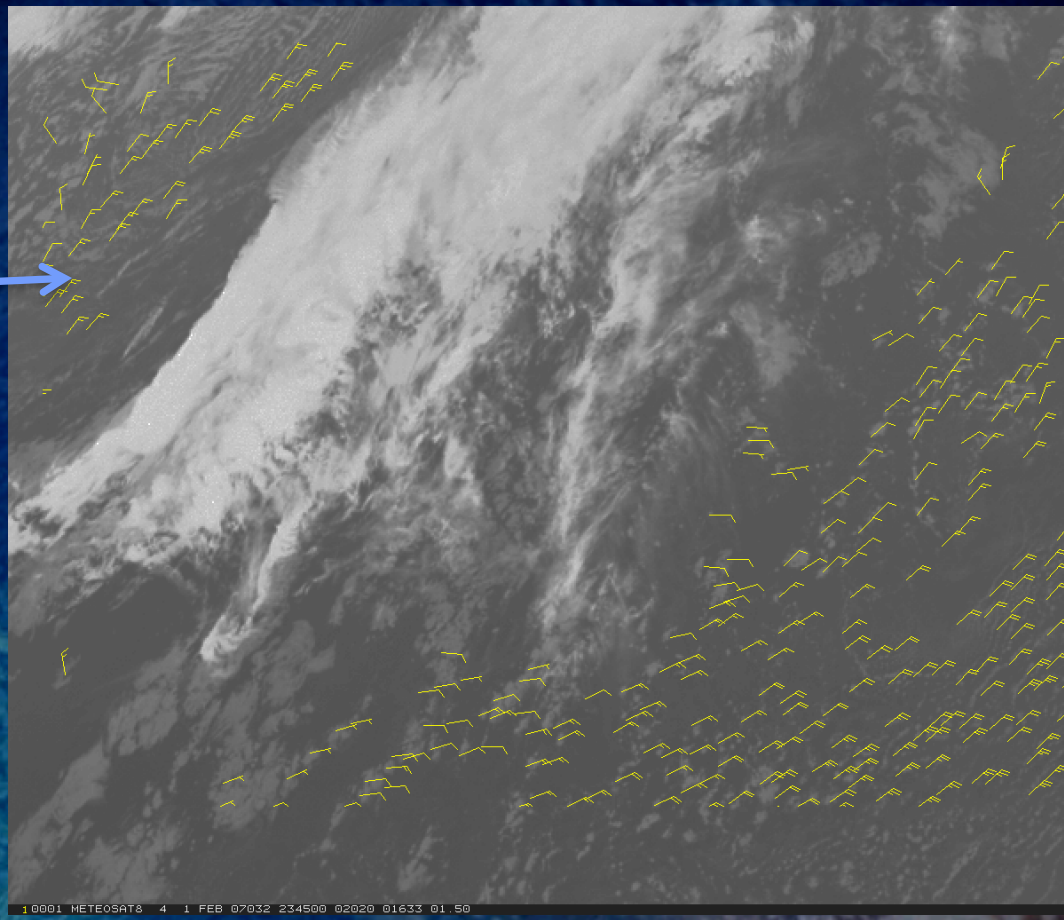
Low-Level >700 mb

Example Output

Short-wave IR Cloud-drift Winds

Cloud-drift Winds derived from a Full Disk Meteosat-8 SEVERI 3.9μm image triplet centered at 0000 UTC 02 February 2007



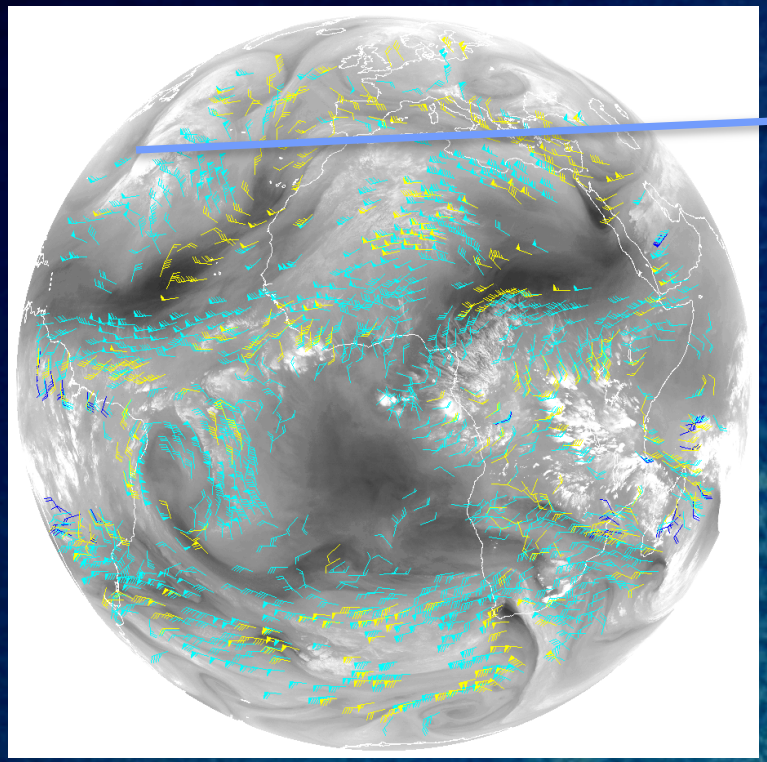


Low-Level >700 mb

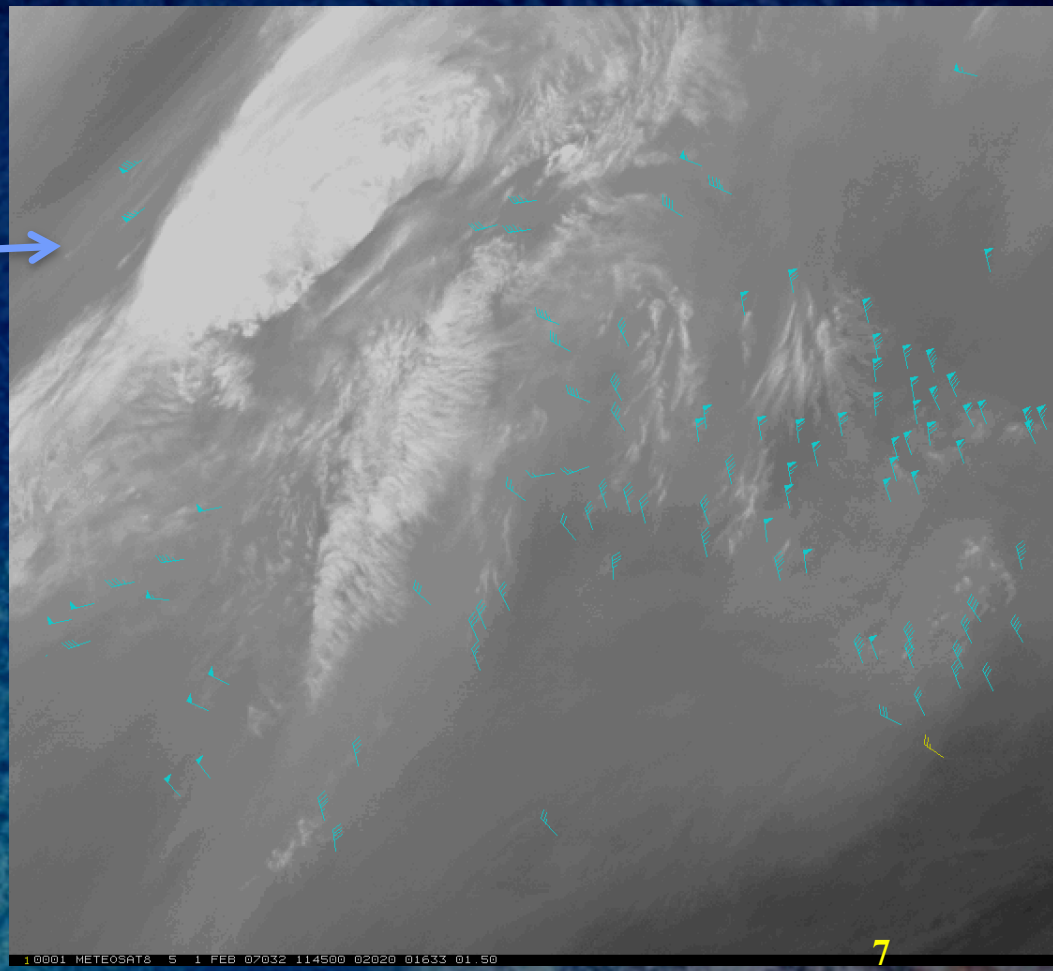
Example Output

Clear-Sky Water Vapor Winds

Clear-sky Water Vapor Winds derived from Full Disk Meteosat-8 SEVERI 6.2um and 7.3um image triplets centered at 1200 UTC 01 February 2007



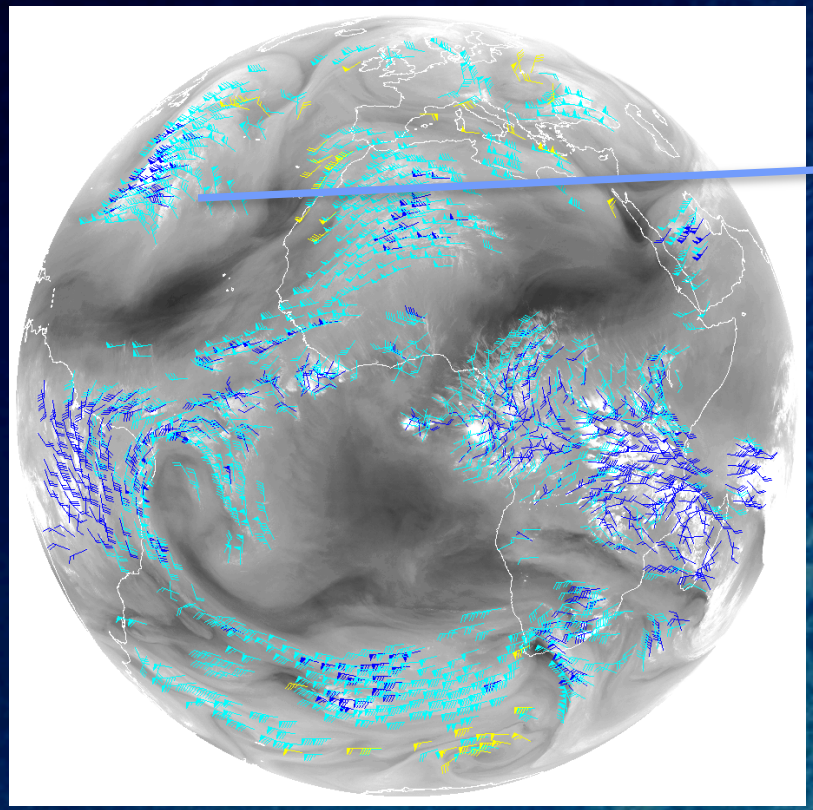
100-400 mb | 250-350 mb | 350-550 mb



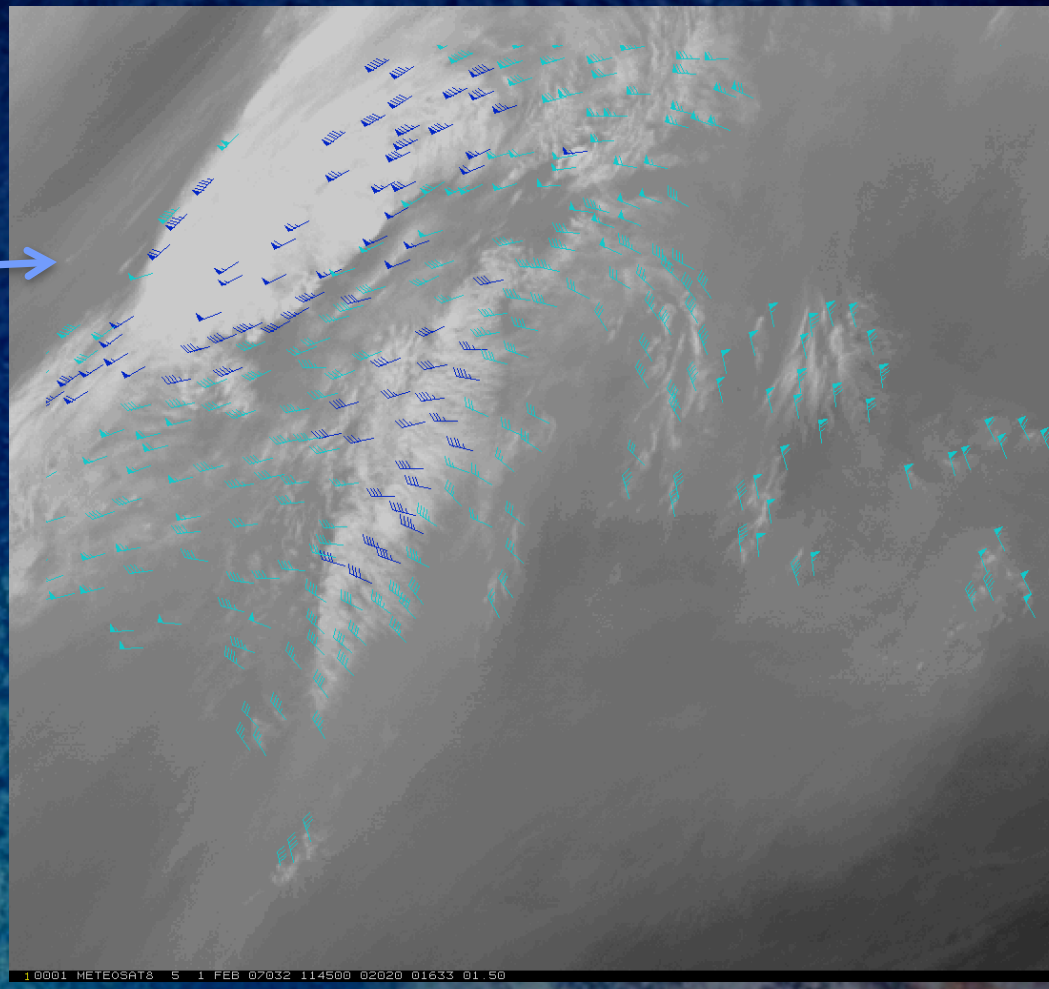
Example Output

Cloud-top Water Vapor Winds

Cloud-top Water Vapor Winds derived from Full Disk Meteosat-8 SEVERI 6.2um image triplet centered at 1200 UTC 01 February 2007



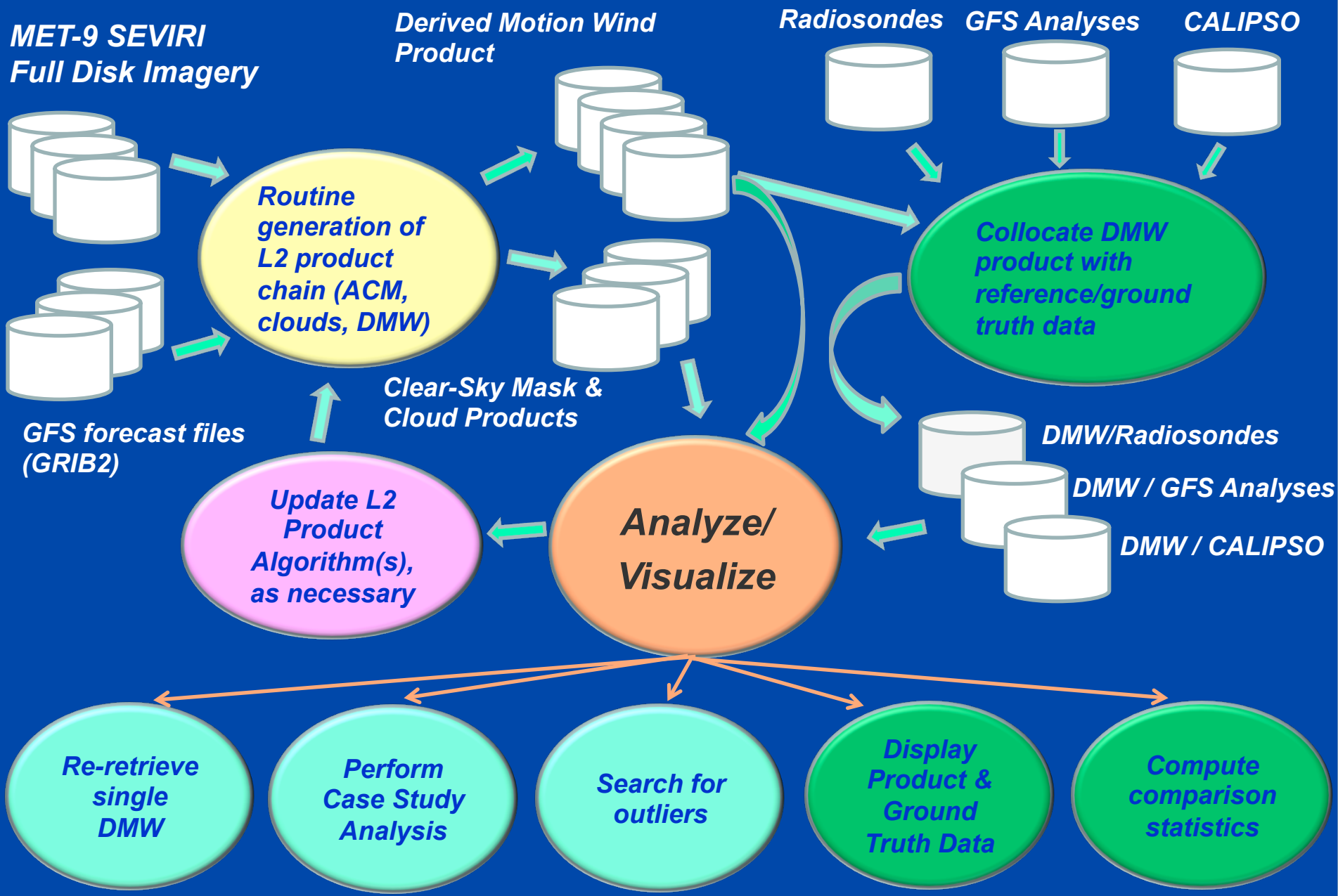
100-400 mb | 250-350 mb | 350-550 mb



Validation Strategies

- Routinely generate Derived Motion Wind (DMW) product in real-time using available ABI proxy data
- Acquire reference/"ground truth" data and collocate DMW product
  - Radiosondes, GFS analysis, Wind profilers
- Analyze and visualize data *(imagery, GFS model, L2 products, intermediate outputs, reference/ground truth)* using available and developed (customized) tools
- Measure performance
- Modify L2 product algorithm(s), as necessary

Validation Strategies



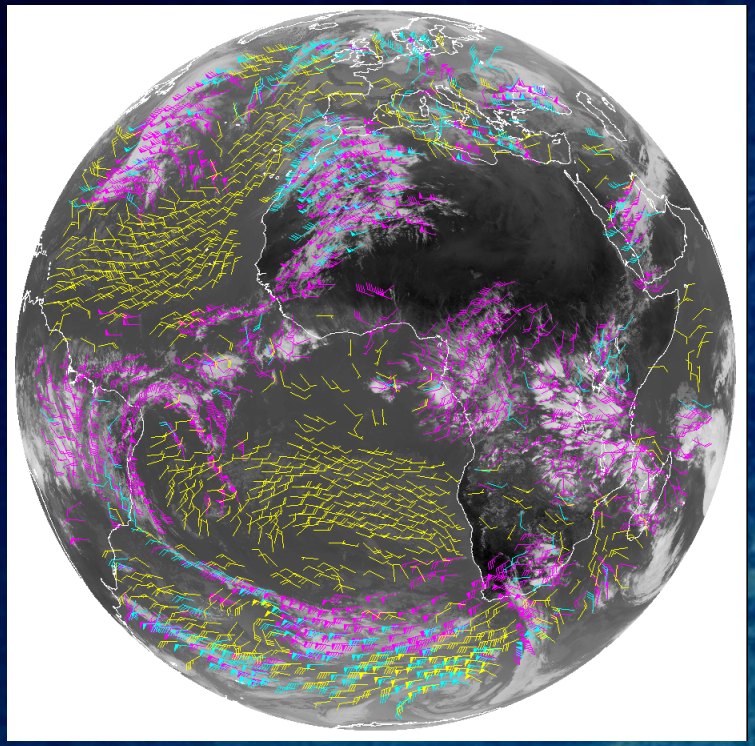
"Routine" Cal/Val Tools

- Targeted for the routine and automated monitoring of operational Level-2 products
- Enable the visualization of products and/or reference ('truth") data
- Perform the routine daily collocation of Level-2 products with their associated reference ("truth") observations and the creation of comprehensive collocation databases
- Enable the generation and visualization of comparison statistics
- Rely on/built upon a variety of existing libraries that that enable data analysis and visualization capabilities
  - Man-computer Interactive Data Access System (McIDAS)
  - Interactive Data Language (IDL)
  - Java
  - Other

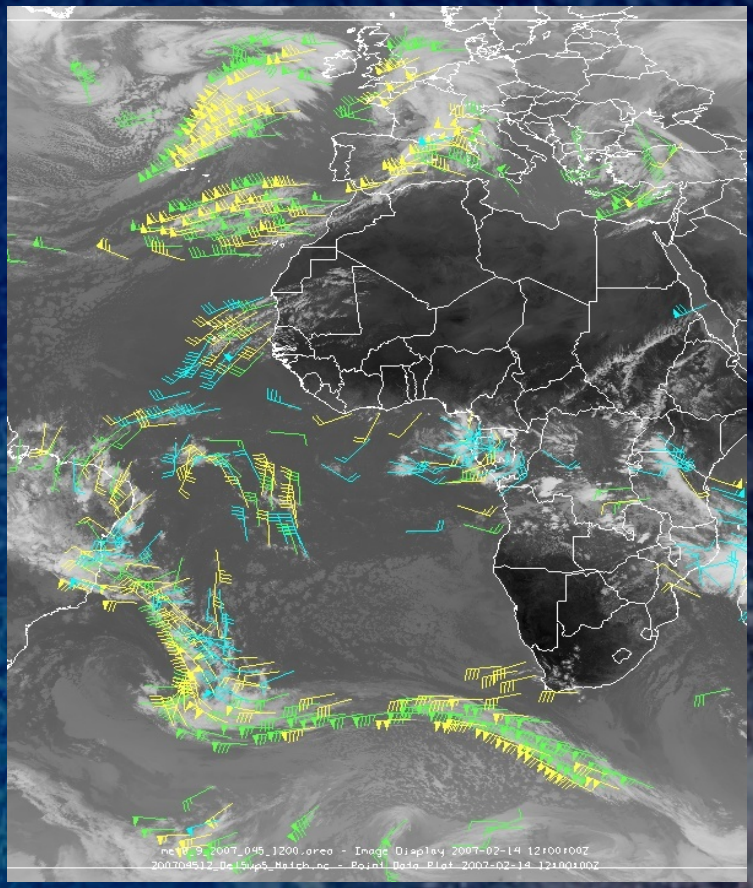
Routine Validation Tools

Product Visualization …

McIDAS-X



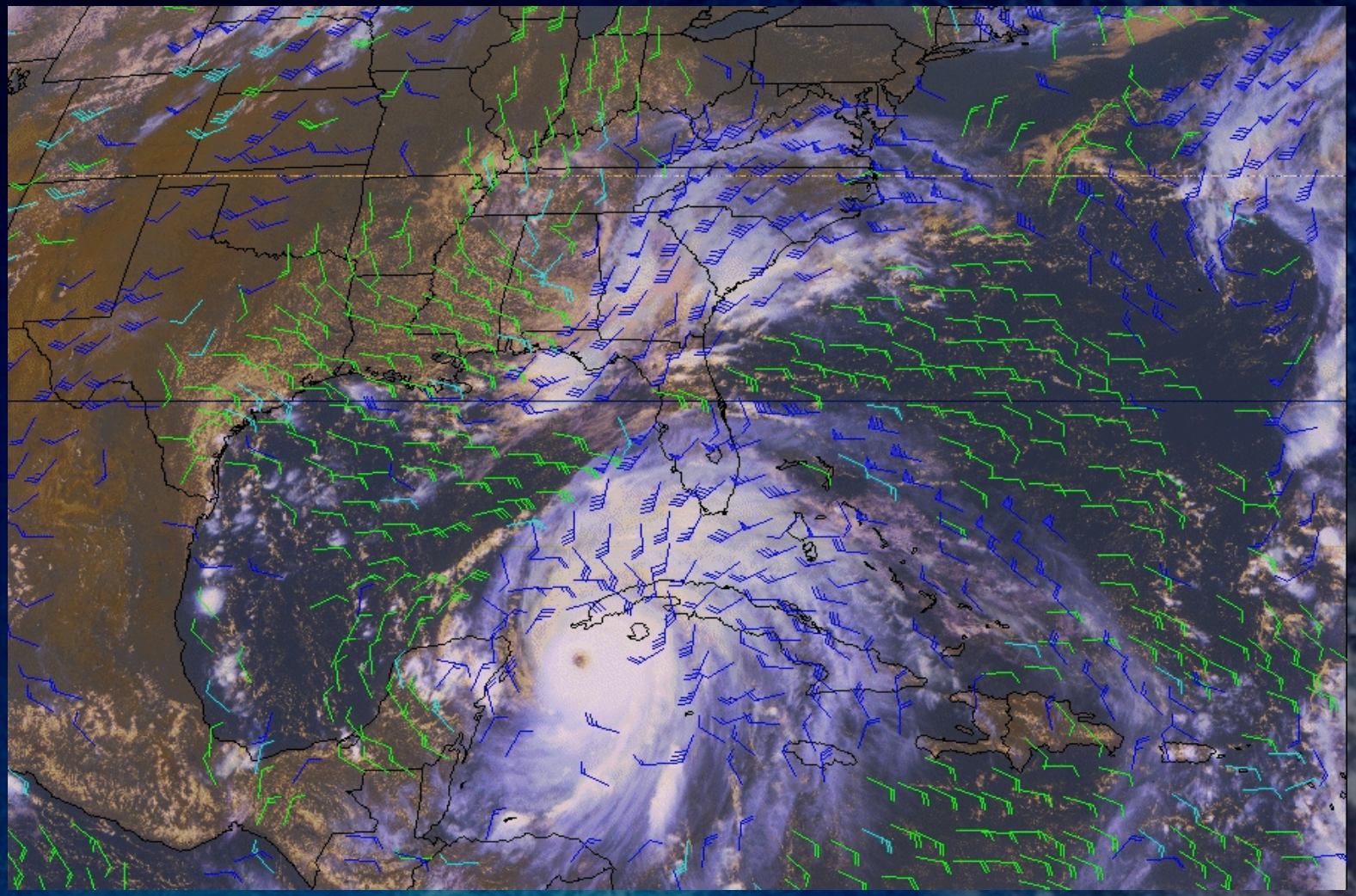
McIDAS-V



Heavy reliance on McIDAS to visualize DMW products, intermediate outputs, diagnostic data, ancillary datasets, and reference/”ground-truth”

Routine Validation Tools

Product Visualization …

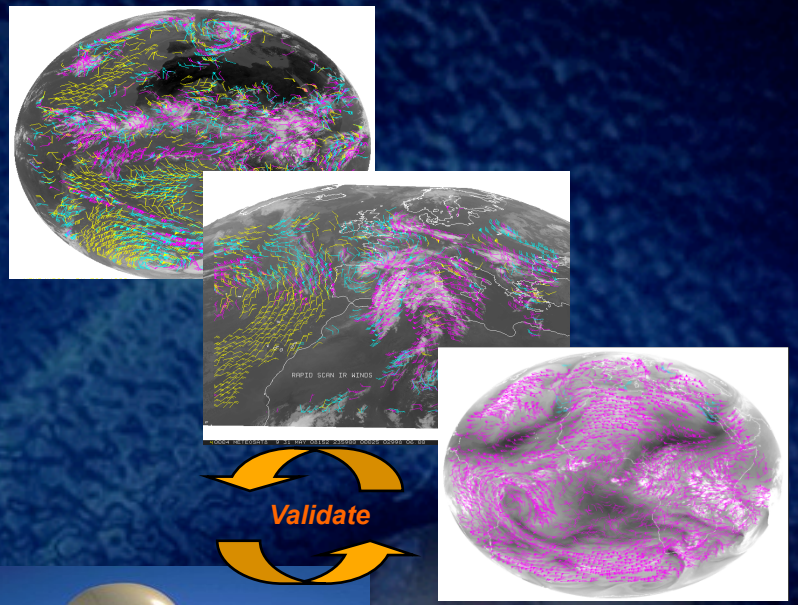


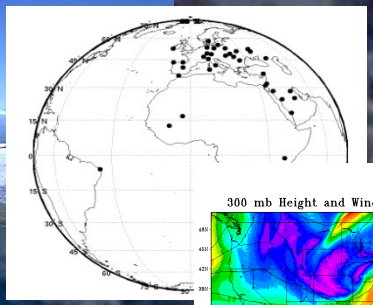
Java-based program written to display satellite winds vectors over a false color image

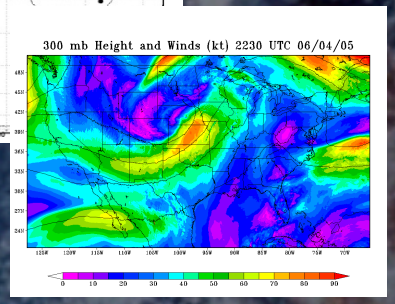
Routine Validation Tools

Collocation Tools…

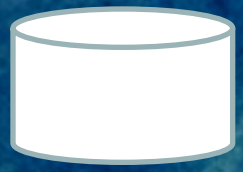
- Collocation Software (DMW and Reference/"Ground Truth" Winds)
  - Radiosondes
  - GFS Analysis
  - Customized code (built on top of McIDAS) to perform the routine daily collocation of Level-2 products with their associated reference ("truth") observations
  - Creation of comprehensive collocation databases that contain information that enables comparisons, "error" analyses



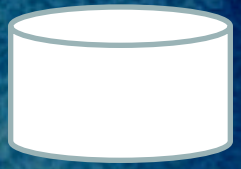




Satellite/Raob winds



Satellite/GFS Winds



Routine Validation Tools

Comparison Statistics…

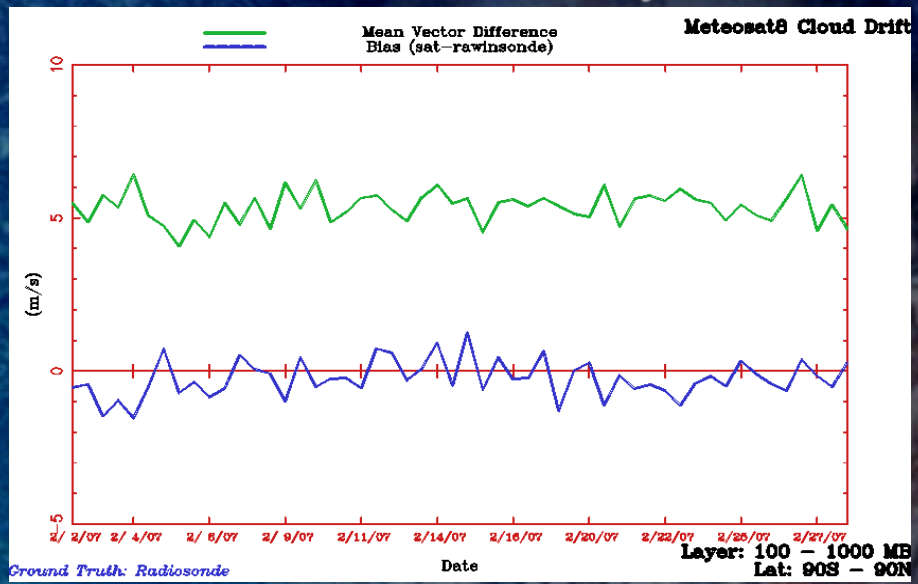
- Customized codes that enable the generation and visualization of comparison statistics
  - Text reports
  - Creation of a database of statistics enabling time series of comparison statistics to be generated
  - Use the PGPLOT Graphics Subroutine Library
    - Fortran- or C-callable, device-independent graphics package for making various scientific graphs
- Visualize contents of collocated databases
  - McIDAS is used

GOES-13 CD WIND RAOB MATCH ERROR STATISTICS

PRESSURE RANGE: 100 - 1000 **LATITUDE RANGE: -90 - 90**

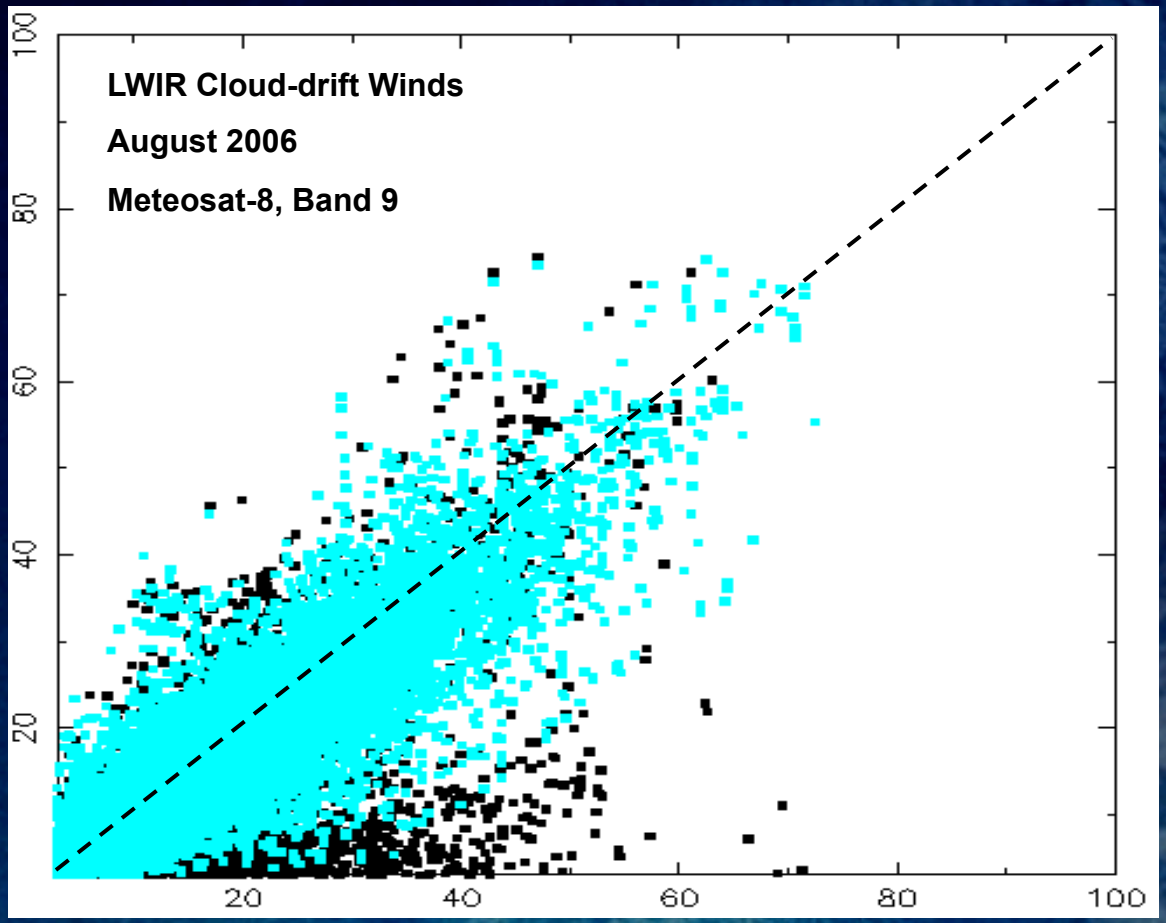
	SAT	GUESS	RAOB
RMS DIFFERENCE (m/s)	6.68	6.11	
NORMALIZED RMS	0.34	0.31	
AVG DIFFERENCE (m/s)	5.51	5.02	
STD DEVIATION (m/s)	3.78	3.48	
SPEED BIAS (m/s)	-0.97	-1.32	
|DIRECTION DIF| (deg)	14.85	15.06	
SPEED (m/s)	18.55	18.20	19.52
SAMPLE SIZE	87100		

Satellite DMW vs. Raob Wind ***OR***
Satellite DMW vs. GFS Analysis Wind



Example Scatter Plot Generated with PGPLOT

Version 3 vs. Version 4 Performance …



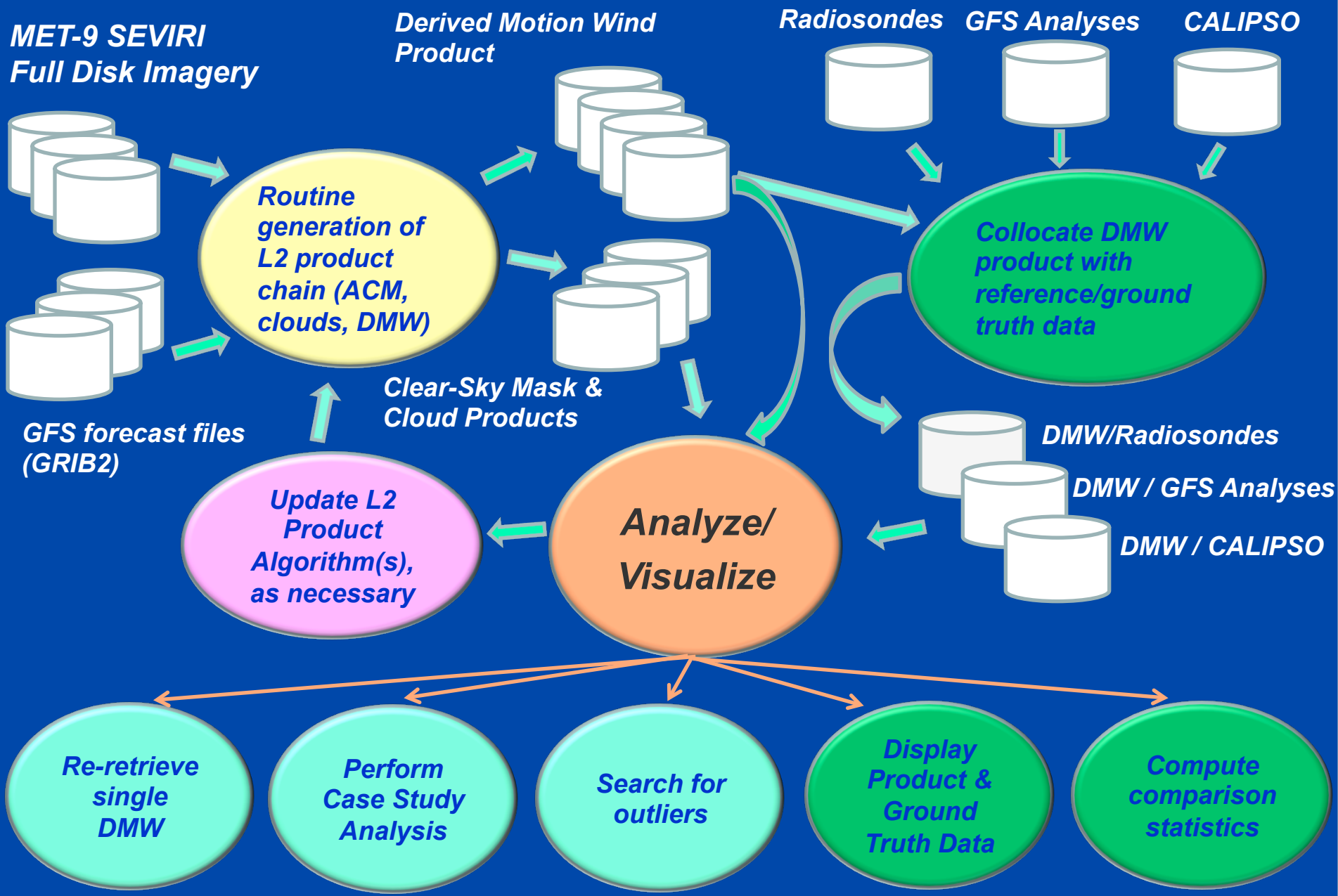
Black – Version 3 Algorithm

RMS:	7.78 m/s
MVD:	6.14 m/s
Spd Bias:	-2.00 m/s
Speed:	17.68 m/s
Sample:	17,362

Light Blue – Version 4 Algorithm (Nested Tracking)

RMS:	6.89 m/s
MVD:	5.46 m/s
Spd Bias:	-0.18 m/s
Speed:	17.91 m/s
Sample:	17,428

Validation Strategies

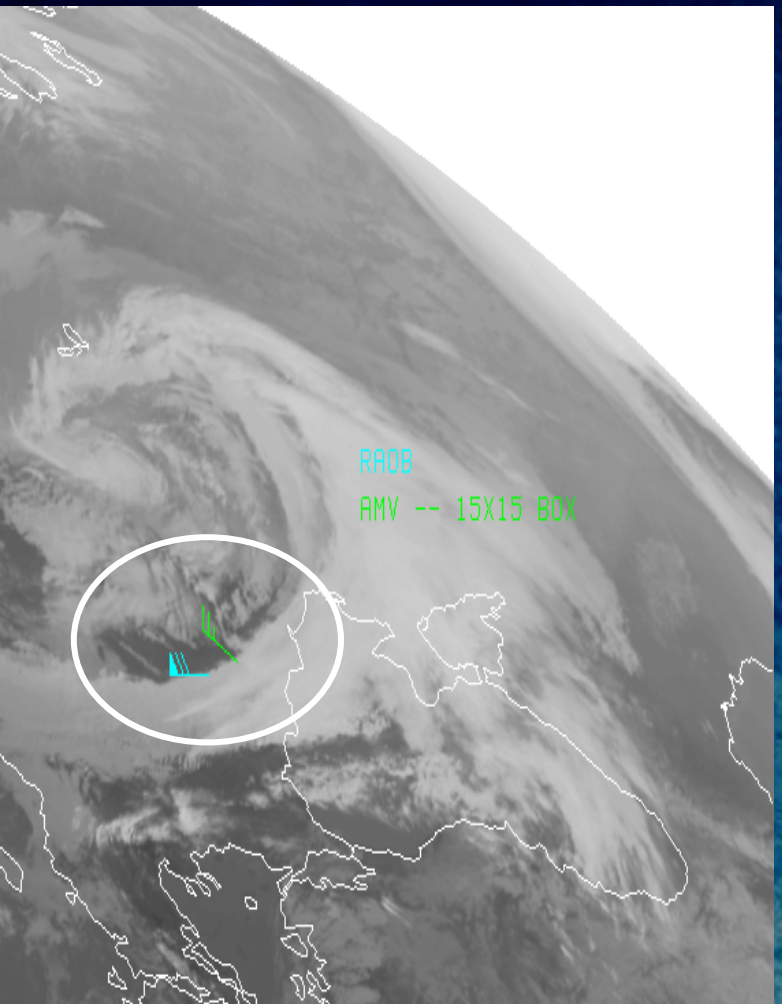


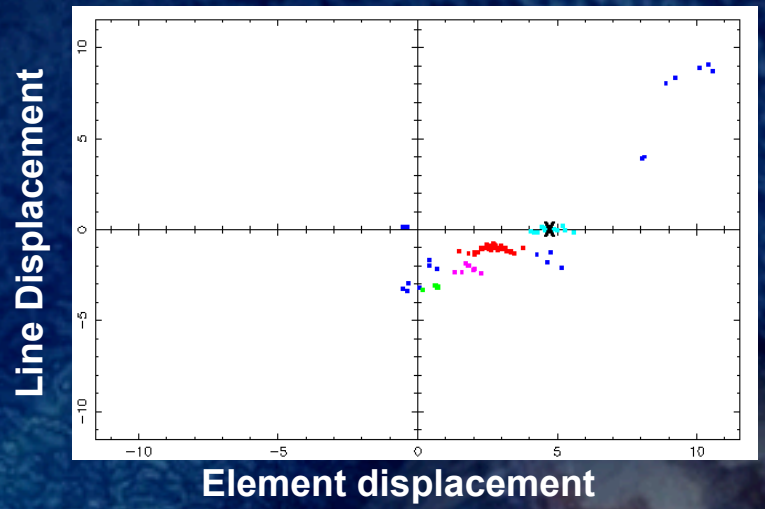
"Deep-Dive" Cal/Val Tools

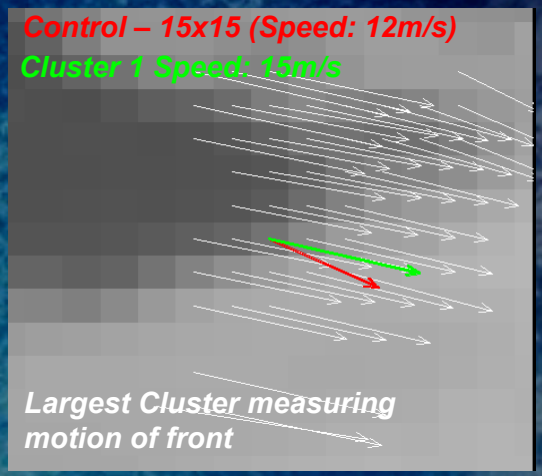
- Set of customized tools targeted for "deep-dive" assessment of Level-2 products in the research and development environment
- Provide algorithm developers with the means to assess the performance of an algorithm, including any and all ancillary and intermediate data needed by the algorithm to generate the product
- May include a product reprocessing capability
  - In whole or individual retrievals
- Enhanced visualization capabilities that enable more detailed scientific analyses
- Rely on/built upon a variety of existing libraries that enable data analysis and visualization
  - Man-computer Interactive Data Access System (McIDAS)
  - Interactive Data Language (IDL)
  - MATLAB
  - Java
  - Other

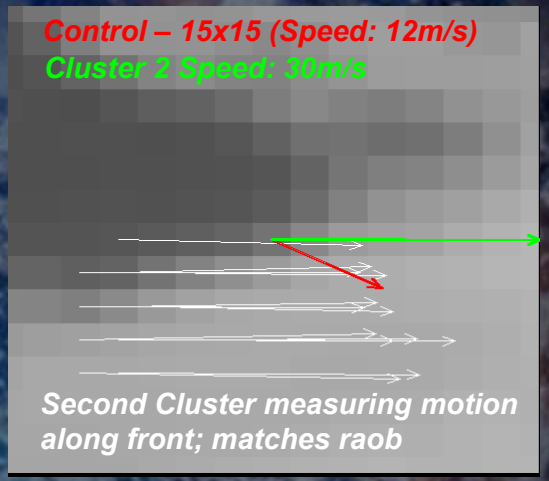
"Deep-Dive" Validation Tools

"Stand-alone re-retrieval & visualization tool " that enables the generation of a single derived motion wind vector for a single target scene and allows for the visualization of wind solution, tracking diagnostics, target scene characteristics . *PGPLOT library used….*







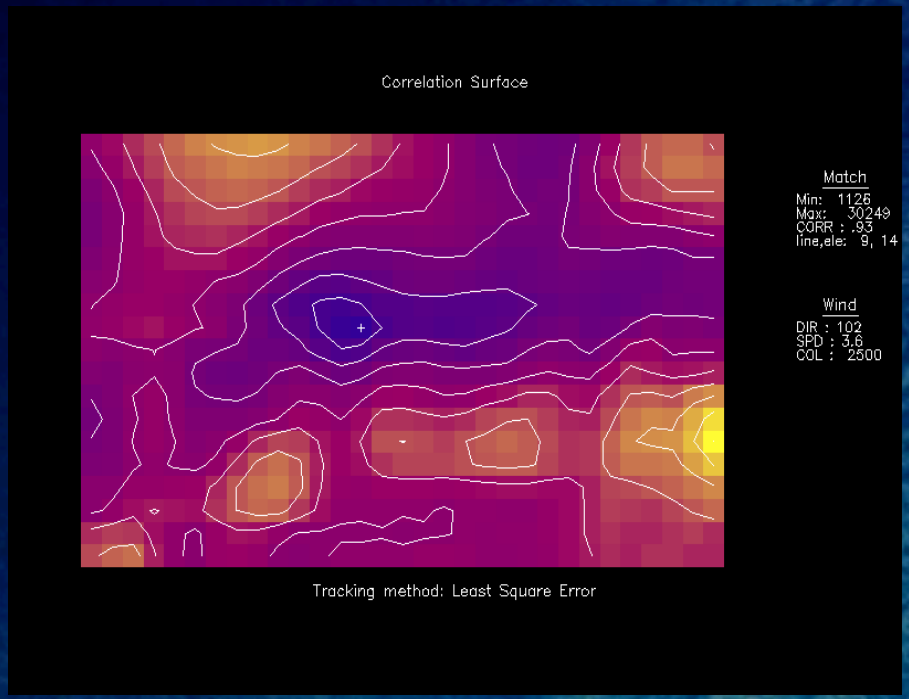


"Deep-Dive" Validation Tools

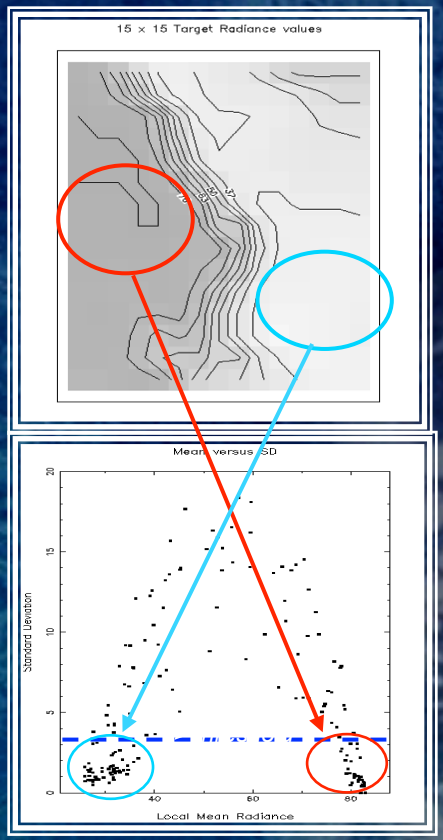
"Stand-alone re-retrieval & visualization tool " that enables the generation of a single derived motion wind vector for a single target scene and allows for the visualization of wind solution, tracking diagnostics, target scene characteristics . *PGPLOT library used….*

Feature Tracking Diagnostics

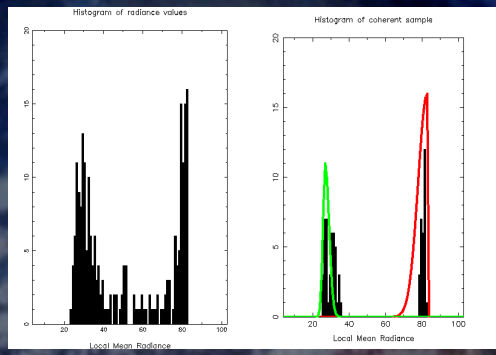
Correlation Surface Plots



Target Scene Characteristics



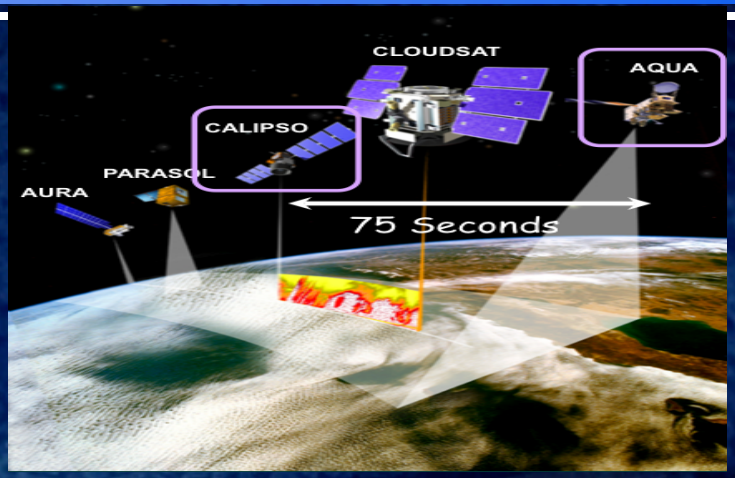
Spatial Coherence Plots



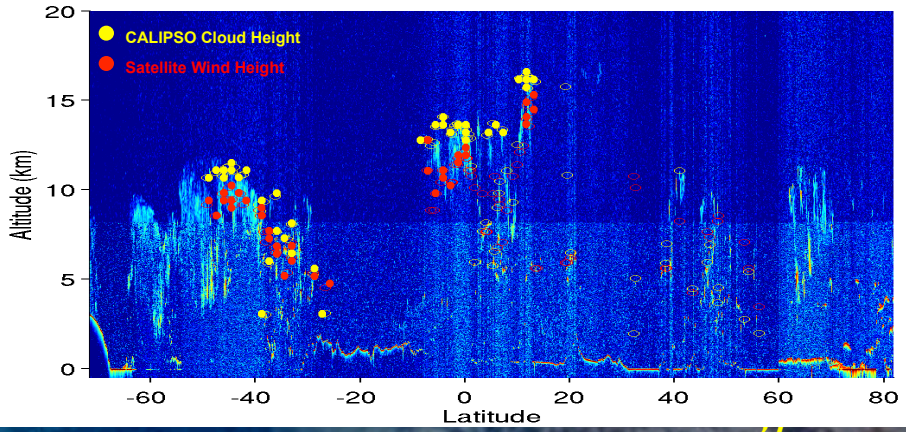
"Deep-Dive" Validation Tools

Using CALIPSO/CloudSat Data to Validate Satellite Wind Height Assignments

- *Winds team continues to work closely with the cloud team on cloud height problem (case studies, most recently)*
- Leverages unprecedented cloud information offered by CALIPSO and CloudSat measurements
- Enables improved error characterization of satellite wind height assignments
- Enables feedback for potential improvements to satellite wind height assignments
- Improvements to overall accuracy of satellite-derived winds



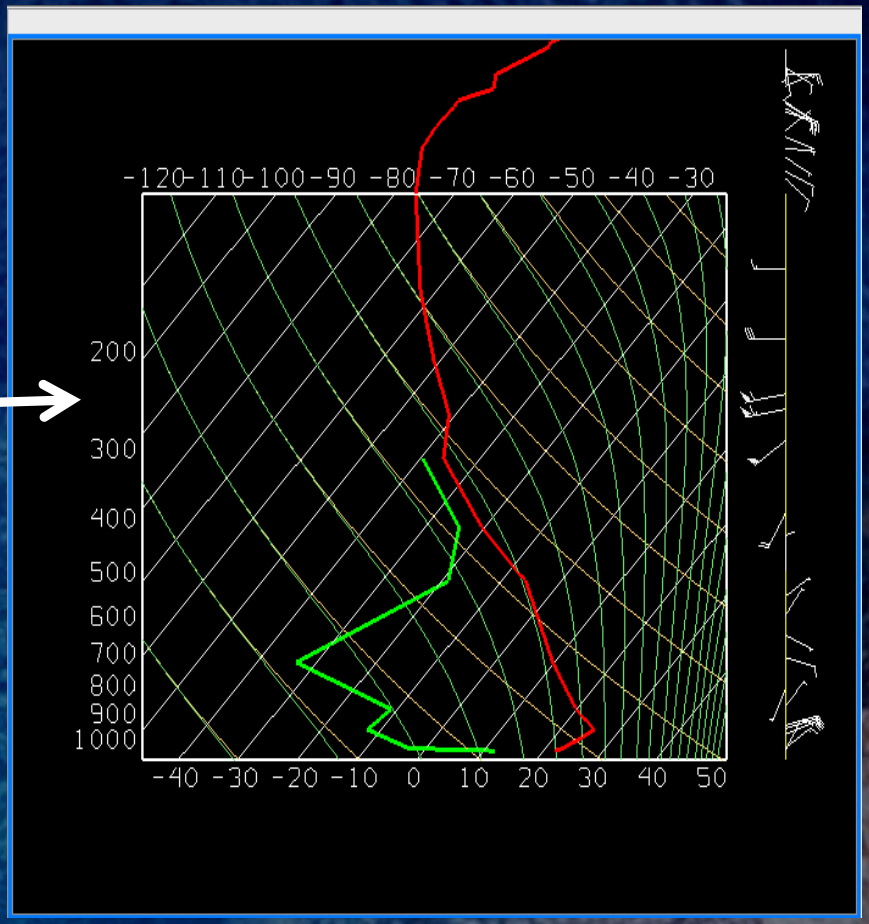
GOES-12 Cloud-drift Wind Heights Overlaid on CALIPSO total attenuated backscatter image at 532nm



Work in progress…

"Deep-Dive" Validation Tools

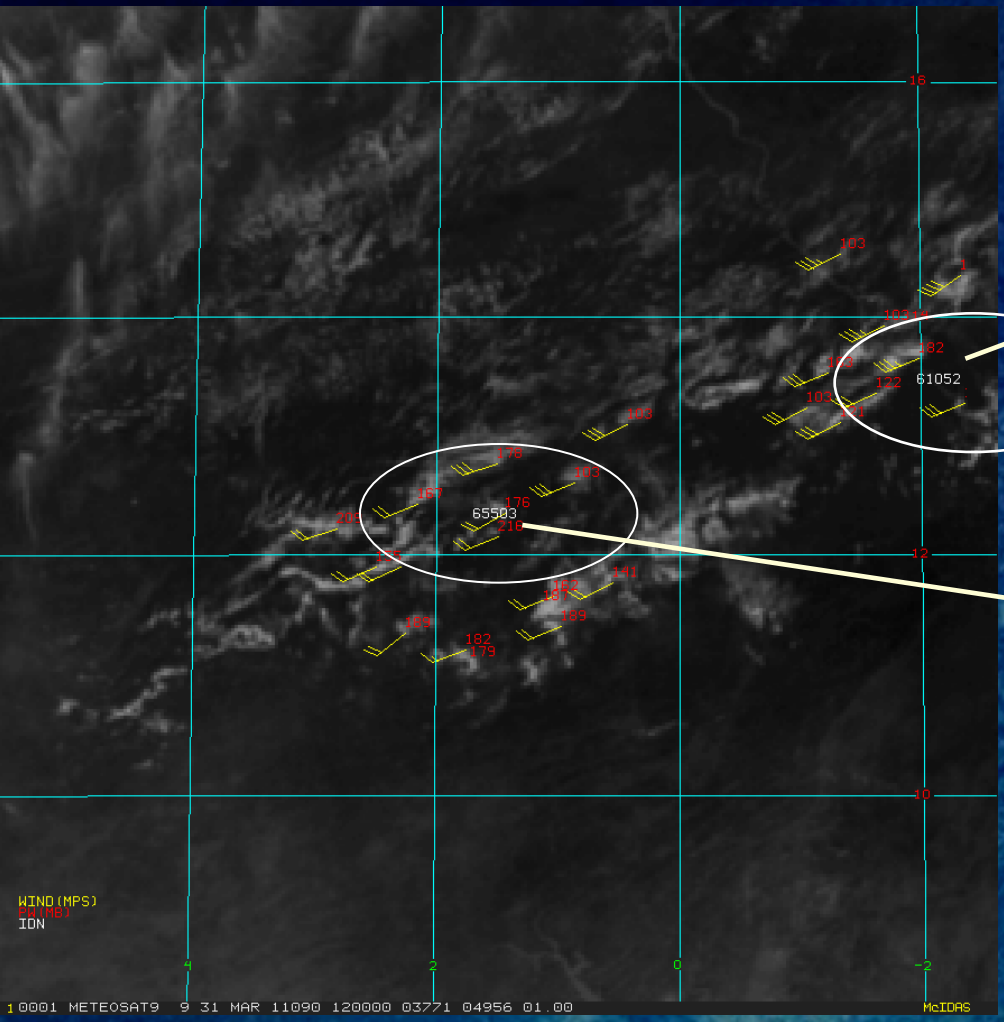
Visualization of reference/"ground truth" data using McIDAS-V…

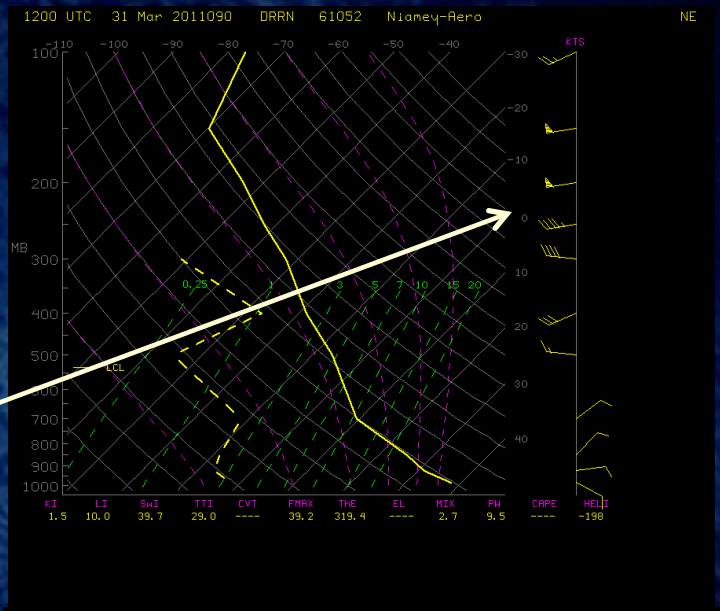


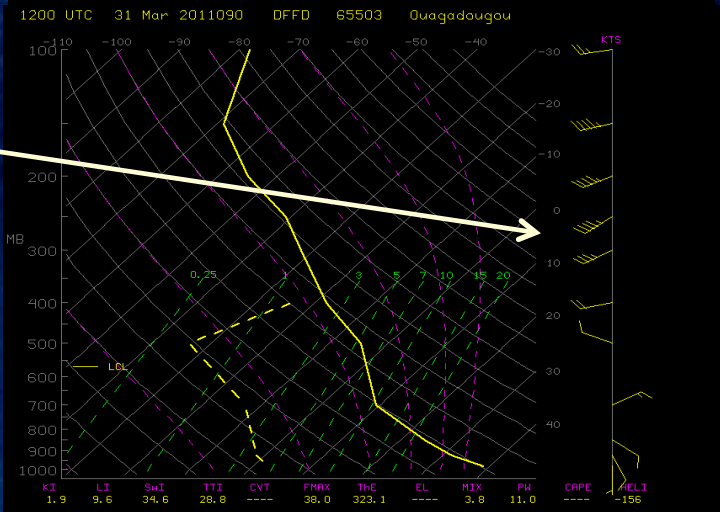
Done using McIDAS-V

”Deep-Dive” Validation Tools

At what height does satellite wind “best fit”?



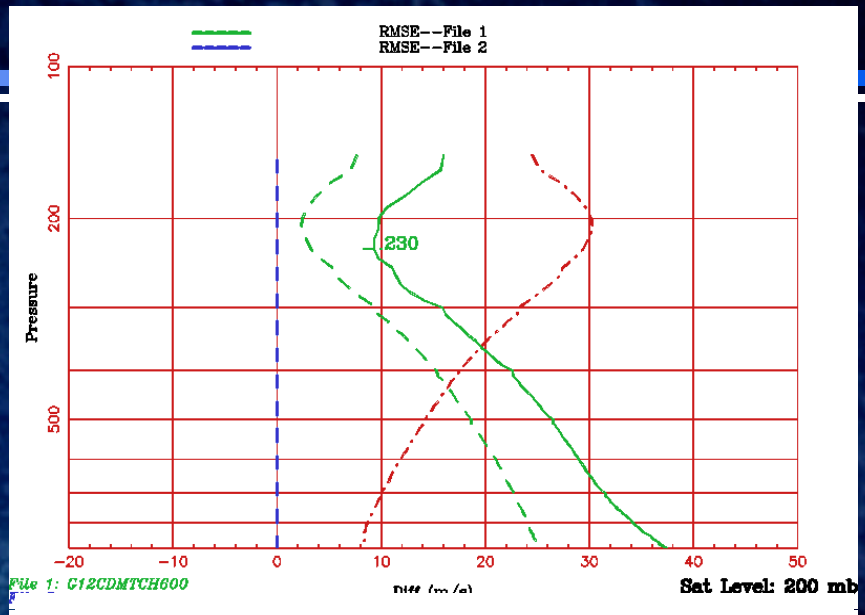


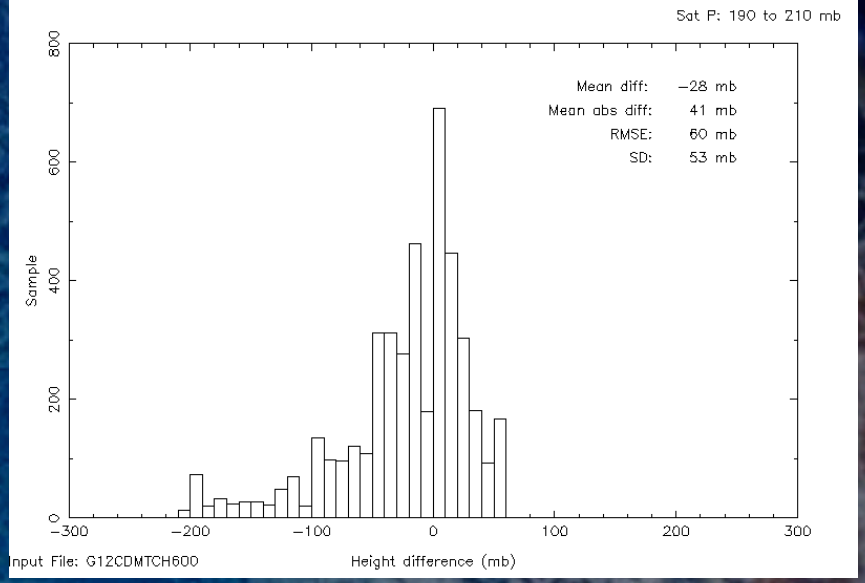


"Deep-Dive" Validation Tools

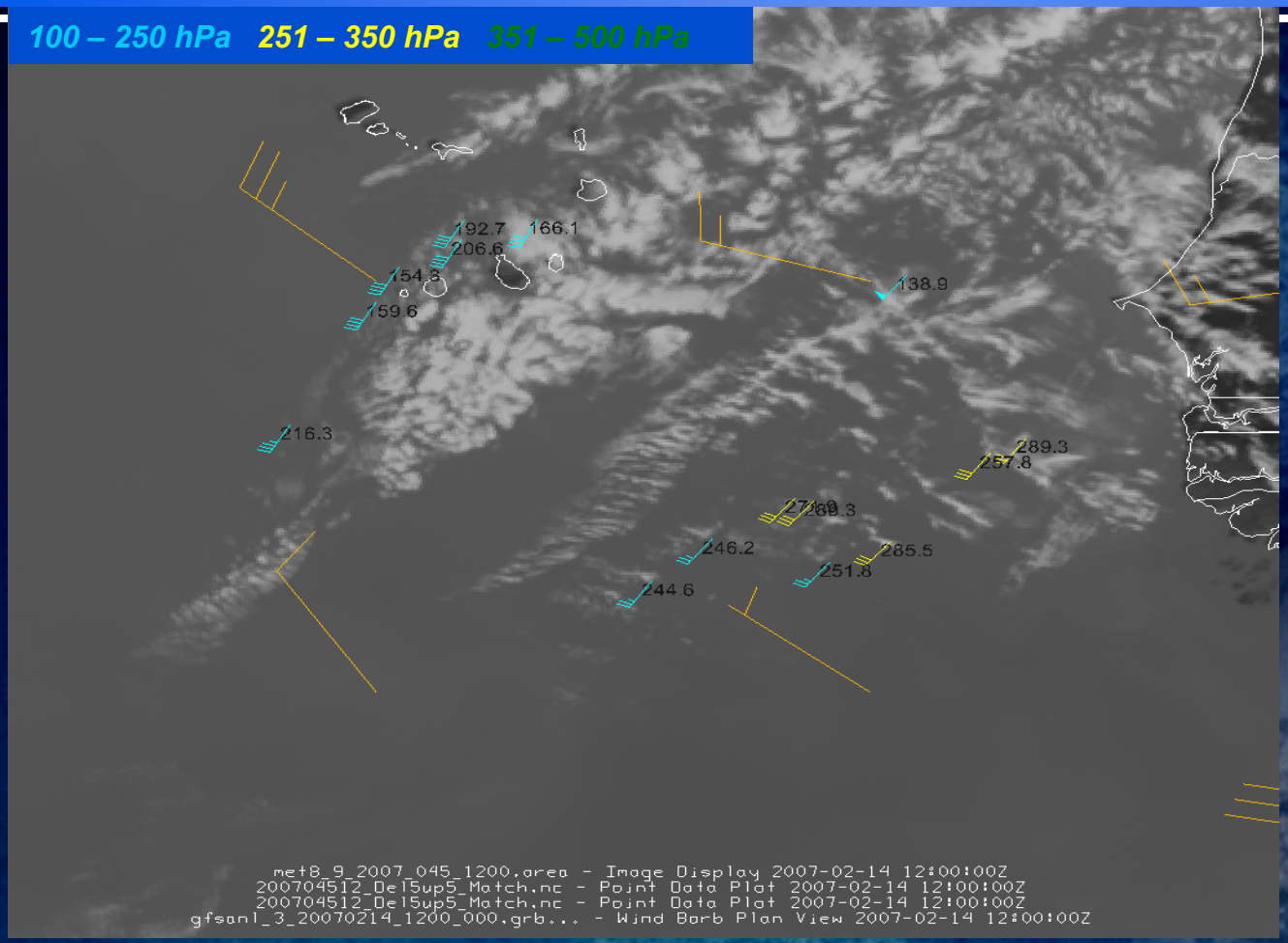
"Level-of-Best-Fit" Assessment of AMVs

- Uses AMVs together with collocated Radiosonde wind profiles over a period of time
- Use these data to characterize the quality of the height assignments
- **Level of Best-Fit** is defined to be the level at which vector difference between the satellite wind and the radiosonde wind is a minimum





"Deep-Dive" Validation Tools



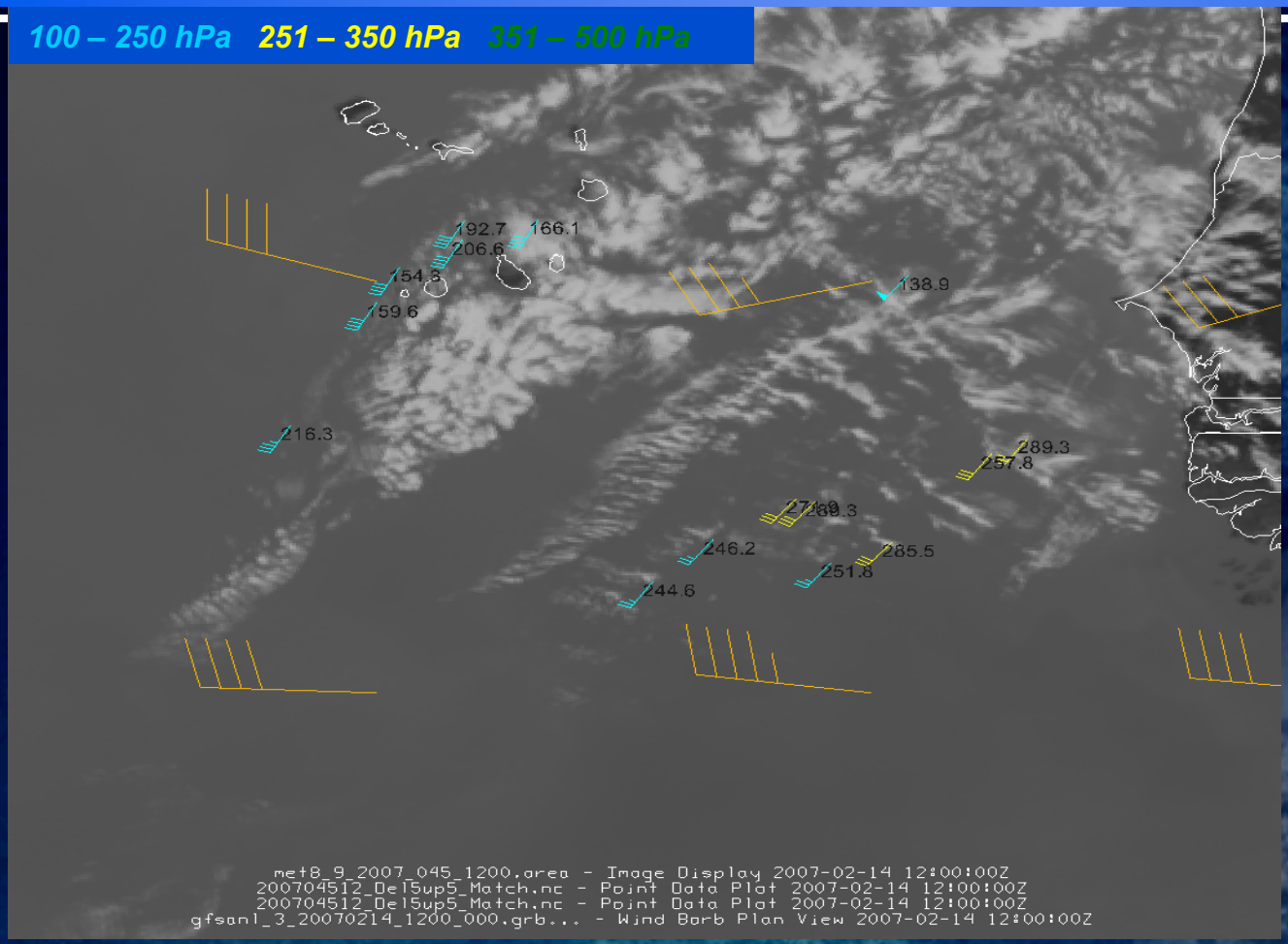
The search for outliers…

Large wind barbs are GFS Analysis winds at 150 hPa.

TC_AP_UNCER_CIRRUS = 40.0

Vector Difference > 20 m/s

"Deep-Dive" Validation Tools



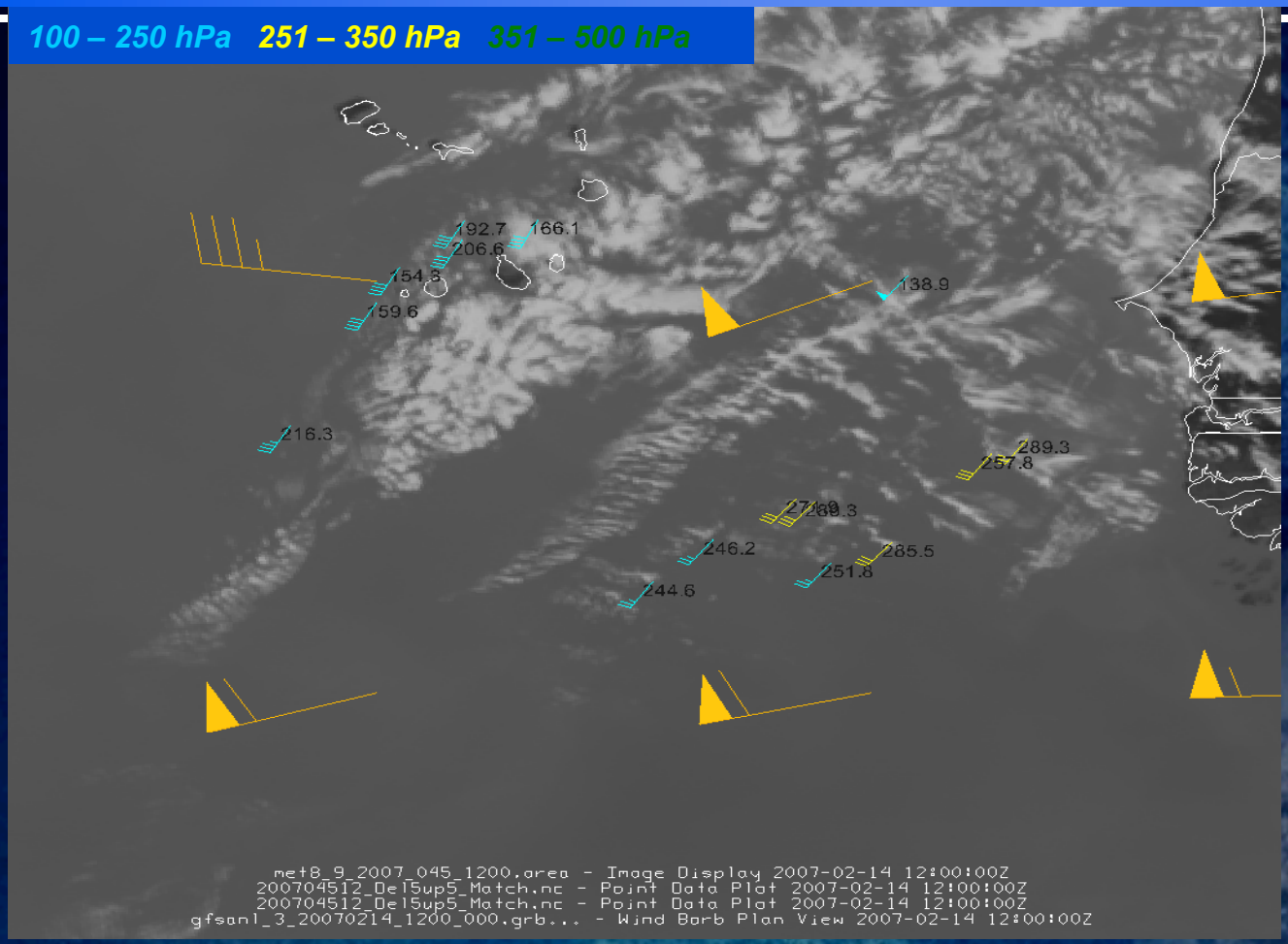
The search for outliers…

Large wind barbs are GFS Analysis winds at 200 hPa.

TC_AP_UNCER_CIRRUS = 40.0

Vector Difference > 20 m/s

"Deep-Dive" Validation Tools



The search for outliers…

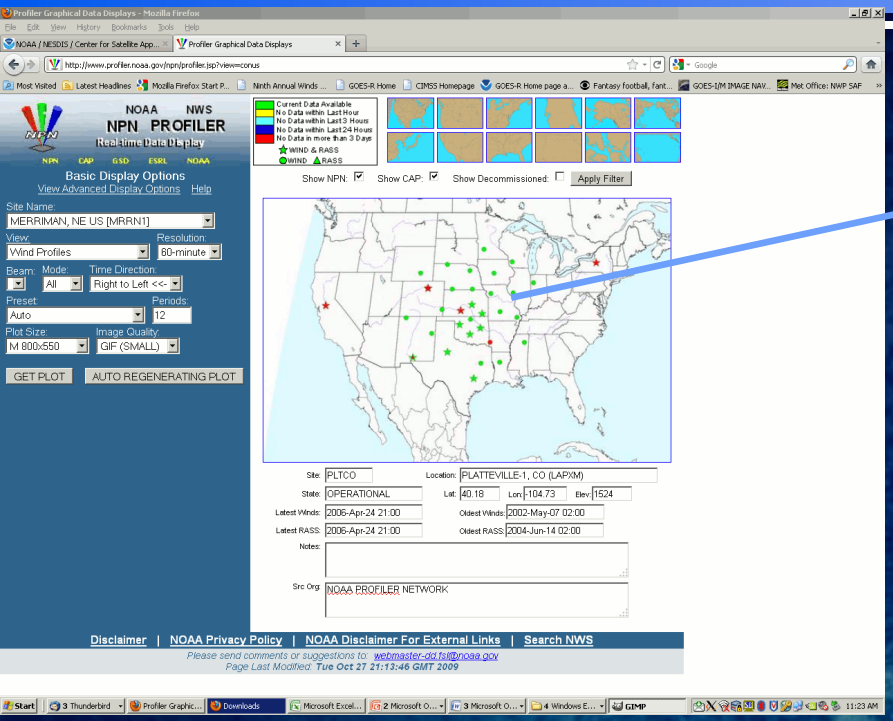
Large wind barbs are GFS Analysis winds at 250 hPa.

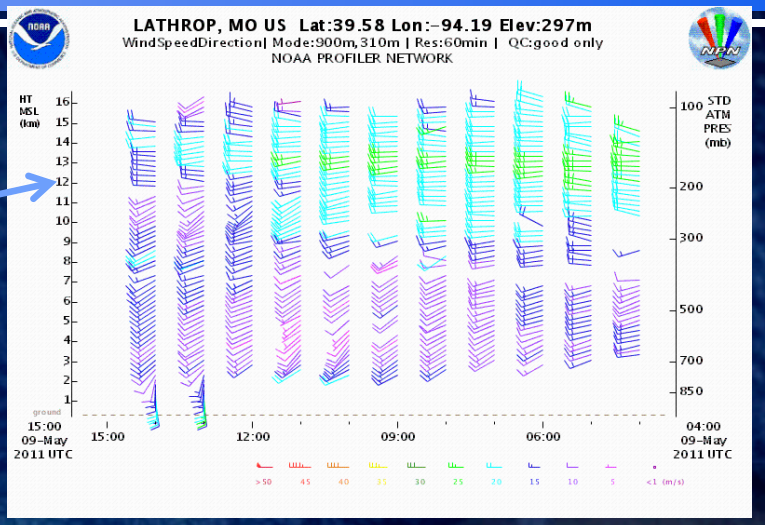
TC_AP_UNCER_CIRRUS = 40.0

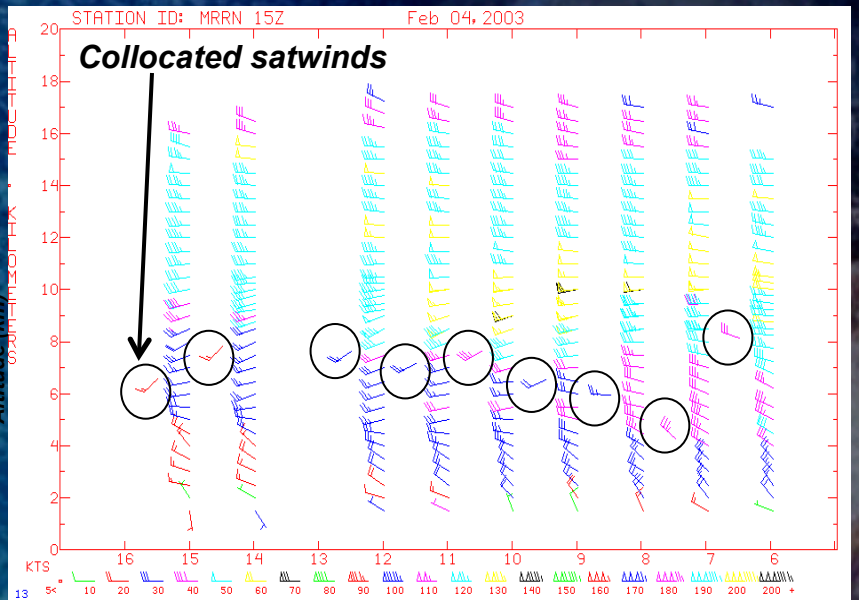
Vector Difference > 20 m/s

"Deep-Dive" Validation Tools

Using NOAA Wind Profilers







Ideas for the Further Enhancement and Utility of Validation Tools

- Enhance some of the McIDAS-V capabilities that would help with wind validation work (ie., displays of vertical wind profiles from different sources including GFS analysis/forecasts, wind profilers, CALIPSO, etc)

- Reprocessing of winds from our matchup databases would be a nice capability to have, but would take a good amount of work and time to do.

- Develop tool needed to generate geometrically-based (stereo, shadows) cloud heights as a means to validate AMV height assignments
  - GOES-based
  - MISR geometrically-based cloud heights

- Develop capability to re-retrieve AMVs from a long-term archive
  - Coordinated effort with NCDC?
  - Would fulfill a long-standing IWWG recommendation that satellite operators reprocess AMVs from data retrieved from their respective archive agencies

Summary

- Routinely generate Derived Motion Wind (DMW) product in real-time using available ABI proxy data
  - Meteosat-9 SEVIRI
  - Search for outliers, analyze and understand (case studies), develop/test algorithm adjustments
- Primary sources of reference/"ground truth" data for DMW product
  - Radiosondes, GFS analysis, Wind profilers, CALIPSO (cloud height)
- Modify DMW L2 product algorithm(s), as necessary
- Plan to demonstrate DMW product in GOES-R Proving Ground demonstration at HPC this summer.
  - Forecaster feedback will support our validation efforts